CATALOGUE OF BRIGHT LINES IN THE SPECTRUM OF THE SOLAR ATMOSPHERE *

WITHOUT waiting to complete my entire report of the spectroscopic work at Sherman, I send for immediate publication, should you think proper, a list of the bright lines observed in the spectrum of the chromosphere during the past summer.

The great altitude of the station (nearly 8,300 ft.), and the consequent atmospheric conditions, were attended with even greater advantages for my special work than had been really expected, although I was never quite able to realise my hope of seeing all the Fraunhofer lines reversed; unless once or twice for a moment, during some unusual disturbances of the solar surface. Everything I saw, however, confirmed my belief that the origin of the dark lines is at the base of the chromosphere, and that the ability to see them all reversed at any moment depends merely upon instrumental power and atmospheric conditions.

In this view, a catalogue of the bright lines actually observed is of course less important than it would be otherwise; still it is not without interest and scientific value, since the lines seen are naturally those which are really most conspicuous in the chromosphere spectrum, and this conspicuousness stands in important, but by no means obvious or even entirely simple, relations to the intensity of the corresponding dark lines, when such exist. There can be no doubt that a careful study of these bright lines and their behaviour would yield much valuable information as to the constitution and habitudes of the solar atmosphere.

In the catalogue, the first column contains simply a reference number: a ‡ refers to a note at the end of the catalogue.

The numbers in the second column refer to my "Preliminary Catalogue," containing 103 lines, which was published a year ago in the *American Journal of Science*. In this column a † indicates that some other observer has anticipated me in the determination and publication of the line. As I have depended for my information almost solely upon the *Comptes Rendus* and the Proceedings of the Royal Society (which give the observations of Lockyer, Janssen, Rayet, and Secchi), it is quite possible that some other lines ought to be marked in the same manner.

The third column, headed K, gives the position of the lines on Kirchhoff's scale, the numbers above G being derived from Thalen's continuation of Kirchhoff's maps. In this column an asterisk denotes that the map shows no corresponding dark line, a ? that the exact position, not the existence, of the line is for some reason slightly uncertain.

The fourth column, headed A, gives the wave-length of the line in ten millionths of a millimetre according to Angstrom's atlas. The numbers in this and the preceding column were taken, not from the maps themselves, which present slight inaccuracies on account of the shrinking and swelling of the paper during the operation of printing, but from the numerical catalogues of Kirchhoff and Angström which accompany their respective atlases. In the preliminary catalogue the numbers were derived from the maps; hence some slight discrepancies in the tenths of division.

The fifth column, marked F, contains a rough estimate of the percentage of frequency with which the lines were seen during the six weeks of observation; and the sixth column, B, a similar estimate of their maximum brightness compared with that of the hydrogen line C.

The variations of brilliance, however, when the chromosphere was much disturbed, were so considerable and so sudden, that no very great weight can be assigned to the numbers given. Nor is it to be inferred that lines which have in the table the same index of brightness were always equally bright. On some occasions one set of lines would be particularly conspicuous, on others, another.

With two or three exceptions, indicated in the notes, no lines have been catalogued which were not seen on at least two different days. In the few cases where lines observed only on one occasion have been admitted to the list, the observations were at the time carefully verified by my assistant, Prof. Emerson, so as to place their correctness beyond a doubt. Many other lines were "glimpsed" at one time and another, but not seen steadily enough or long enough to admit of satisfactory determination.

The last column of the catalogue contains the symbols of the chemical elements corresponding to the respective lines. The materials at my disposal are the maps of Kirchhoff and Angstrom, Thalen's map of the portion of the solar spectrum above G, and "Watts's Index of Spectra." Since the positions of the lines in the latter work are given only to the nearest unit of "Angstrom's scale," I have marked the coincidences indicated by it with a (w), considering them less certain than those shown by the maps.

In addition to the elements before demonstrated to exist in the chromosphere, the following seem to be pretty positively indicated—sulphur, cerium, and strontium; and the following with a somewhat less degree of probability, zinc, erbium, and yttrium, lanthanum and didymium. There are some coincidences also with the spectra of oxygen, nitrogen, and bromine, but not enough, considering the total number of lines in the spectra of these elements, or of a character to warrant any conclusion. One line points to the presence of iridium or ruthenium, and only three lines are known in the whole spectrum of these metals. The reversal of the H's deserves also especial notice.

No one, of course, can fail to be struck with the number of cases in which lines have associated with them the symbols of two or more elements. The coincidences are too many and too close to be all the result of accident, as for instance in the case of iron and calcium, or iron and titanium.

Two explanations suggest themselves. The first, which seems rather the most probable, is that the metals operated upon by the observer who mapped their spectra, were not absolutely pure—either the iron contained traces of calcium and titanium, or *vice versâ*. If this supposition is excluded, then we seem to be driven to the conclusion that there is some such similarity between the molecules of the different metals as renders them susceptible of certain synchronous periods of vibrations—a resemblance, as regards the manner in which the molecules are built up out of the constituent atoms, sufficient to establish between them an important physical (and probably chemical) relationship. I have prefixed to the catalogue a table showing the number of lines of each substance, or combination of substances, observed in the chromosphere spectrum, omitting, however, oxygen, and nitrogen, and bromine, since with one exception (line 230), neither of them ever stands alone, or accounts for any lines not otherwise explained.

The instruments and methods of observation were the same as those employed in the construction of the Preliminary Catalogue. Telescope, $9\frac{4}{10}$ inches aperture—spectroscope automatic, with dispersive force of 12 prisms.

The approximate geographical position of Sherman is long. 1h. 53·2m. west of Washington, lat. 41° 07′; altitude above sea-level 8,280 feet; mean height of barometer about 22·1 inches.

Table showing the number of coincidences between the bright lines observed in the spectrum of the chromosphere, and those of the spectra of the chemical elements.

Fe, Ti, $S_{(w)}$	1	Ti, $S_{(w)}$	3	*Unknown.*	52	Total.
" Ba, $S_{(w)}$	1	" Ca,	2			
" $S_{(w)}$ $Zn_{(w)}$	1	" Mn,	1	Fe,	64	110
" Co, Ce,	1	" Cr,	1	Ti,	23	43
" Ni, $E_{(w)}$	1			Ca,	10	29
Ca, Cr, Ce,	1	" Sr,	1	Ba,	8	13
" Li, Zn,	1	" Zn,	1	$S_{(w)}$	7	14
Ti, Ba, $S_{(w)}$	1			Mn,	6	12
Ba, La, $E_{(w)}$	1	Ca, Cd,	1	Ce,	5	11
		" Ce,	1	H,	4	4
Fe, Ca,	10	Ca, Co,	1	Na,	4	6
" Ti,	9	" Cr,	1	Cr,	4	10
" Mn,	4	" Sr,	1	Mg,	3	4
" Cr,	3			Sr,	3	6
" Ni,	3	$S_{(w)}$ $E_{(w)}$	1	Zn,	3	9
" Ba,	2			$E_{(w)}$	2	9
" Zn,	2	Mn, Zn,	1	Ni,	2	6
" $E_{(w)}$	2			Co,	1	5
		Cr, $E_{(w)}$	1	Cu,	1	2
" Ce,	1			La,	1	3
" Co,	1	Ce, Co,	1	Ru, Ir,	1	1
" Mg,	1			Cd,		1
" Na,	1	Na, Cu,	1	Li,		1
" $S_{(w)}$	1					
" La,	1	lines marked with an *	14			

The numbers in the last column denote the whole number of times that the symbol of each element appears in the catalogue, either singly or combined with others.

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* Letter to the Superintendent of the U. S. Coast Survey, containing a Catalogue of Bright Lines in the Spectrum of the Solar Atmosphere, observed at Sherman, Wyoming Territory, U. S. A., during July and August, 1872; by Prof. C. A. Young, of Dartmouth College. Reprinted from advance sheets of the *American Journal of Science and Art*.

Catalogue of Bright Lines in the Spectrum of the Chromosphere. 1872.

No	PC.	K.	A.	F.	B.	E.
1‡	1†	534·0*	7055·?	100	12	
2	2†	654·3	6676·9	25	50	Fe, Ba$_{(w)}$
3	3†	C.694·1	6561·8	100	100	H,
4		711·4	6515·5	15	4	
5	4	718·7	6496·0	18	5	Ba,
6		731·7	6461·7	5	2	Ca.
7	5	734·0	6453·8	10	6	
8		740·9	6438·1	5	2	Ca, Cd,
9‡	6	744·3	6429·9	20	4	
10		750·1	6415·6	5	2	
11		756·9	6399·0	5	2	Fe,
12		759·3	6392·6	5	1	Fe,
13		767·?*	6373·?	5	2	
14	7	768·?*	6371·?	5	3	
15		778·3	6346·1	10	4	Ruth, Ir,
16‡	8	823·5	6245·4	8	5	Fe,
17‡	9	827·6	6237·3	8	2	
18		830·2	6231·5	5	1	Fe,
19		836·5	6218·3	3	1	Ti,
20		839·2	6214·1	3	1	Ti,
21		845·7	6199·6	2	2	Fe,
22		849·7	6190·5	10	2	Fe,
23		859·7	6168·3	3	1	Ca,
24		863·9	6161·2	8	3	Ca,
25		870·9	6148·1	3	2	Fe, E$_{(w)}$
26		871·4	6146·8	3	2	
27	10	874·3	6140·6	25	10	Ba,
28		876·5	6136·1	2	1	
29		877·0	6135·6	2	1	Fe,
30		884·9	6121·2	5	3	Ca, Co,
31		890 2	6109·9	2	1	Ba,
32		894·9	6101·7	3	2	Ca, Li, Zn$_{(w)}$
33		903·1	6083·1	3	2	Ti,
34		912·1	6064·5	5	2	Fe, Ti,
35		933·8	6018·0	2	1	Ba,
36‡		949·4	5990·0	10	4	
37		992·0	5913·2	2	1	Fe,
38	11†	D$_1$1002·8	5895·0	50	30	Na,
39	12†	D$_2$1006·8	5889·0	50	30	Na,
40‡	†	1011·2	5883·0	2	1	Fe,
41‡	13†	D$_3$1016·5*	5874·9	100	90	
42		1031·8	5852·7	8	2	Ba,
43		1135·1	5708·3	1	1	Fe
44		1151·1	5687·2	2	1	Na,
45		1154·2	5683 5	5	3	
46		1155·8	5681·5	2	1	Na, Fe, N$_{(w)}$
47		1165·7	5667·8	2	2	S$_{(w)}$
48		1167 0	5666 0	1	1	
49		1170·6	5661·5	15	2	Fe, Ti, E$_{(w)}$
50		1175·0	5656·7	8	3	S$_{(w)}$ N$_{(w)}$
51		1176·6	5654·4	2	1	Fe,
52		1187·1	5640·2	1	1	S$_{(w)}$
53		1189·3	5637·3	1	1	
54		1200 6	5623·2	2	1	Fe,
55		1207·3	5614·5	2	1	Fe,
56		1229·6	5587·6	2	2	Ca,
57		1231·3	5585·5	2	1	Fe,
58	14†	1274·2	5534·1	50	12	Ba, Fe, Sr,
59	15	1281·3	5525·9	40	5	Fe,
60		1287·5	5518·7	15	2	Ba,
61		1298·9	5505·8	2	1	Fe,
62		1303·5	5500·5	2	1	Fe, La,
63		1306·7	5496·6	2	1	Fe, E$_{(w)}$
64		1320·6	5480·2	2	1	Ti, Sr,
65		1324·8	5475·9	1	1	Ni,
66		1328·7	5472·3	3	1	
67		1337·0	5462·3	1	1	Fe, N$_{(w)}$
68	16	1343 5	5454·7	10	4	Fe,
69	17	1351·1	5445·9	10	4	Fe, Ti, Br$_{(w)}$
70		1360·9	5435·4	5	2	Zn, Br$_{(w)}$
71		1362·9	5433·0	2	2	Fe,
72‡	18	1364·3	5431·8	8	5	
73	19	1367·0	5428·8	8	3	Fe, Ti,
74	20	1372·1	5424·5	25	6	Ba, Ti, S$_{(w)}$
75	21	1377·4	5417·9	5	2	Ti, Mn,
76		1380·5	5414·5	2	2	Fe,
77	22	1382·5	5412·4	4	2	Mn$_{(w)}$
78		1384·7	5410·0	2	1	Fe, Ni,
79		1385·7	5409·0	2	2	Cr,
80		1389·4	5404·8	2	1	Fe,
81	23	1390·9	5403·1	5	3	Fe, Ti,
82		1394·2	5399·6	2	1	Mn,
83	24	1397·5	5396·1	4	2	Fe, Ti,
84		1401·6	5392·2	2	1	Fe, Ce,
85		1412·5	5380·2	3	2	Ti,
86	25†	1421·5	5370·5	10	3	Fe,
87		1423·0	5369·0	1	1	Fe,
88		1425·4	5366·5	1	1	Fe,
89		1428·2	5364·0	1	1	Fe,
90	26†	1430·1	5361·9	20	10	Fe,
91		1438·9	5352·4	4	2	Fe, Co, Ce,
92		1446·7	5345·0	1	1	
93		1450·8	5340·2	1	2	Fe, Mn, O$_{(w)}$
94	27	1454·7	5335·9	5	2	Ti, Zn$_{(w)}$
95		1461·5	5329·1	6	4	
96	28	1462·8	5327·1	5	2	Fe,
97	29	1463·3	5327·6	5	2	Fe,
98		1464·8	5325·1	6	2	
99		1471·9*	5318·0	1	1	
100‡	31†	1473·9	5315·9	90	50	Fe,? O$_{(w)}$?
101		1476·8	5313·1	3	1	
102		1497·3	5292·0	1	1	Cu, Br$_{(w)}$
103	32	1505·3	5283·4	20	10	Ti$_{(w)}$
104	33†	1515·5	5275·0	30	15	
105	34	E$_1$1522·7	5269·5	15	4	Fe, Ca,
106	35	E$_2$1523·7	5268·5	12	3	Fe,
107	36†	1527·7	5265·8	10	4	Fe, Co,
108		1530·2	5263·3	1	1	Ca, Br$_{(w)}$
109		1538·5*	5256·2	2	1	Sr,
110		1541·9	5254·1	1	2	Fe, Mn,
111		1547·7	5249·7	3	1	Fe, Z$_{(w)}$ Br$_{(w)}$
112		1551·6	5246·3	3	1	Fe,
113	37	1561·0	5239·0	4	2	Fe,
114	38	1564·2	5236·3	4	2	
115	39†	1567·5	5233·6	10	8	Mn, Zn$_{(w)}$
116	40	1569·6	5232·1	1	3	Fe,
117		1575·4	5227·5	1	1	Sr,?
118	41	1577·4	5226·2	10	3	Fe,
119		1578·1	5225·5	2	3	Sr, Br$_{(w)}$
120	42	1580·1	5224·3	2	2	Ti,
121		1589·1	5216·5	2	1	Fe,
122		1590·7	5215·5	3	2	Fe,
123		1592·3	5214·4	2	1	Fe,
124		1597·9*	5210·5	1	1	
125		1598·9	5209·5	1	2	Ti,
126	43	1601·5	5207·6	10	6	Fe, Cr,
127	44	1604·4	5205·2	10	6	Cr, E$_{(w)}$
128	45	1606·4	5203·7	10	6	Cr, Fe,
129	46	1609·2	5201·5	5	3	Fe,
130	47	1611·3	5199·7	4	2	S$_{(w)}$ E$_{(w)}$
131		1613·9	5197·9	1	1	Fe,
132	48†	1615·6	5197·0	15	10	
133		1617·4	5195·0	1	1	Mn,
134		1618·9	5194·1	2	2	Fe,
135		1627·2	5188·2	10	5	Fe, Ca,
136		1628·2	5187·3	1	1	Ti,
137		1631·5	5185·1	5	2	Fe, Ti,
138	49†	b$_1$1634·1	5183·0	50	30	Mg,
139	50†	b$_2$1648·8	5172·0	50	35	Mg,
140	51†	b$_3$1653·7	5168·3	40	30	Fe, Ni, Br$_{(w)}$
141	52†	b$_4$1655·6	5166·7	30	20	Fe, Mg,
142		1666·?	5160·?	1	1	
143		1671·5	5154·8	3	1	Na,
144	53	1673·7	5152·5	3	1	Na, Cu,?
145	34	1677·9	5150·1	2	2	Fe, Br$_{(w)}$
146		1689·5	5142·2	1	2	S$_{(w)}$
147		1701·8	5133·0	1	1	Fe,
148		1704·7	5130·8	1	1	Fe,
149		1707·9	5128·6	1	1	Ti,
150		1710·7	5126·7	1	1	Fe, Ti,
151		1712·2	5125·5	1	2	
152‡		1713·4	5124·4	1	1	Fe,

No.	PC.	K.	A.	F.	B.	E.
153		1715·2	5123·2	1	1	Fe,
154		1717·9	5121·0	1	1	Fe,
155		1719·4	5119·9	1	1	Ti,
156‡		1727·3	5114·9	1	1	Ni,
157		1734·6	5108·8	2	2	Ti$_{(w)}$
158		1737·7	5107·0	1	1	Fe,
159		1750·4	5098·1	1	1	Fe,
160		1752·8	5096·5	1	1	Fe, S$_{(w)}$
161		1765·0*	5087·0	2	1	E$_{(w)}$
162		1771·5	5083·5	1	1	Zn$_{(w)}$
163	55	1778·5	5077·9	1	2	Fe,
164		1823·6	5047·8	2	2	Fe,? Zn$_{(w)}$
165		1833·4	5041·2	2	2	Fe, Ca,
166		1834·3	5040·1	2	2	Fe,
167		1848·9	5030·1	4	3	S$_{(w)}$
168		1856·9	5023·5	3	1	S$_{(w)}$
169	56†	1867·1	5017·6	30	15	Fe, Ni,
170	57†	1870·6	5015·0	30	10	Ti$_{(w)}$
171		1905·1	4993·3	2	1	Fe, N$_{(w)}$
172‡		c.1961·0	4956·7	1	2	Fe,
173	58†	1989·5	4933·4	30	8	Ba,
174	59†	2001·6	4923·1	40	12	Fe, S$_{(w)}$ Zn$_{(w)}$
175	60†	2003·2	4921·3	30	8	S$_{(w)}$
176	61	2007·2	4918·2	20	3	Fe,
177		2016·0	4911·2	3	2	Zn$_{(w)}$
178	62†	2031·1	4899·3	30	6	Ba, La, E$_{(w)}$
179	63†	2052·5?*	4882·9	10	4	Ce,
180		2067·8	4869·4	5	1	
181	64†	F$_1$2080·0	4860·6	100	80	H,
182		2087·6	4854·7	5	2	Fe, Ni, E$_{(w)}$
183		2094·0	4848·1	3	2	Ca, O$_{(w)}$
184		2116·?*	4826·5	1	1	
185		2121·2	4822·8	10	2	Mn,
186		2142·4	4804·4	3	1	Ti, S$_{(w)}$ O$_{(w)}$
187		2171·5	4778·7	3	2	Co, N$_{(w)}$
188		2229·1	4730·8	1	1	Fe,
189‡		2251·3*	4712·5	2	2	Ce, O$_{(w)}$
190		2309·5	4666·3	3	1	Fe, Ti,
191		2314·3	4663·3	2	1	
192		2323·0	4656·0	2	1	Ti,
193	65	2358·4	4629·0	15	8	Ti, N$_{(w)}$
194		2359·5*	4628·2	2	1	Ce,
195		2369·7	4620·3	1	1	
196		2410·2	4589·4	1	1	
197		2412·8	4587·5	2	2	
198	66	2419·3	4583·2	15	6	
199		2429·5	4576·0	4	2	
200	67	2435·5	4571·4	10	4	Ti,
201	68	2443·9	4564·8	10	3	
202	69	2446·6	4563·2	10	5	Ti.
203		2452·1	4559·5	8	2	
204		2454·1	4558·1	8	1	
205	70	2457·9	4555·3	10	5	Fe, Ti,
206	71	2461·2	4553·4	10	5	Ba,
207		2463·4	4551·8	1	1	Ti, S$_{(w)}$
208	72	2467·6	4548·9	10	8	Ti,
209		2480·8	4539·2	2	1	Ce,
210	73	2486·6	4535·5	2	2	Ti, Ca,
211	74	2489·4	4533·2	5	5	Fe,
212		2490·5	4532·1	3	2	Ti, Ca,
213	76	2502·2	4524·4	3	2	Ba, Fe,
214	77	2505·6	4522·0	3	3	Ti, S$_{(w)}$
215		2517·0	4514·0	2	1	
216		2518·4	4513·0	1	1	
217		2527·0	4506·0	2	1	
218	78	2537·1	4500·3	15	6	Ti,
219	79	2552·4	4490·9	20	8	Mn,
220	80	2555·0	4489·4	15	3	Fe, Mn,
221	81	2566·3	4480·9	5	2	Mg,
222‡	82†	f.2581·2	4471·2	100	25	Ce,
223	83	2585·4	4468·5	20	5	Ti, O$_{(w)}$
224		2620·8	4446·3	1	1	Ti,
225	84	2625·2	4443·0	10	2	Ti,
226		2633·0	4436·7	1	1	Mn?
227		2639·6	4433·5	1	1	
228		2651·5*	4426·0	2	3	
229		2653·2	4425·0	2	2	Ca,
230		2664·9	4418·0	2	1	O$_{(w)}$
231		2665·9	4417·5	3	1	Ti,
232	85	2670·0	4414·7	1	1	Fe, Mn, O$_{(w)}$
233		2680·0	4407·7	1	1	Fe, Ca,
234		2686·8	4404·2	1	1	Fe,
235		2696·0	4398·5	1	1	Ti, Ce, O$_{(w)}$
236		2698·2	4396·5	1	2	
237	87	2702·5	4394·6	15	3	
238		2715·2	4388·5	1	1	Fe,
239	88	2718·5	4384·7	8	2	Ca, Ce,
240		2720·2	4383·5	1	1	
241	89	2721·6	4382·8	1	1	Fe, Cr,
242		2725·8	4380·4	1	1	
243		2728·0	4379·1	1	1	Ca,
244	90	2733·7	4375·5	5	3	Fe,
245	91	2736·9	4374·2	8	3	E$_{(w)}$
246		2762·0	4359·1	1	1	Cr,
247	92	2775·7	4351·8	3	1	Cr,
248	93†	2795·7	4340·1	100	65	H,
249		2798·0	4338·2	10	2	Cr,
250		2805·4	4335·1	2	1	La,
251		2823·4	4324·0	1	2	
252		2830·7	4320·1	1	1	Ti, O$_{(w)}$
253		2843·0	4313·5	1	1	Ti.
254	94	G.2854·2	4307·2	3	2	Ca, Fe,
255	95	2867·7	4302·1	3	2	Ca, Fe,
256	96	2874·2	4298·0	1	1	Ca, Fe,
257	97	2894·5	4289·4	1	1	Cr, Ca, Ce$_{(w)}$
258	98	2928·5	4274·6	2	1	Cr, Ca,
259	99	2961·2	4260·0	2	1	Fe,
260	100	2996·2	4245·2	30	3	Fe,
261		3018·0	4235·5	30	5	Fe,
262		3022·8	4233·0	15	5	Fe, Ca,
263	101	3040·0	4226·3	3	3	Ca, Sr,
264	102	3061·8	4215·3	40	7	Ca, Sr,
265		3155·5	4178·8	1	1	
266		3187·0	4166·7	1	1	Ca,
267	103†	h. 3363·5	4101·2	100	50	H,
268		3431·0	4077·0	25	2	Ca,
269		3526·0	4045·0	3	2	Fe,
270		3703·3	3990·?	2	1	
271		3769·5	3970·?	2	1	Fe,
272‡		H$_1$3778·5	3967·9	75	3	Fe, Ca,
273‡		H$_2$3882·5	3932·8	50	1	Fe, Ca,

Notes

1. The position assigned to this line, first observed by Respighi (a fact of which I was ignorant when the Preliminary Catalogue was published), rests upon two series of micrometric measurements, referring it to four neighbouring dark lines—the probable error is about $\frac{1}{20}$th of a division of Kirchhoff's scale.

9. No. 6 in P C. Position there given, 743?

16 and 17. Nos. 8 and 9 of P C. Position given as 816·8 and 827·6, by a mistake in identifying lines upon the map.

40. I have never myself seen this line reversed. Prof. Emerson, however, saw it several times. It was first reported by Rev. S. J. Perry, in NATURE, vol. iii. p. 67.

41. The position of this line has been independently determined by three series of micrometric comparisons with neighbouring lines. My result agrees exactly with that of Huggins.

72. Erroneously given in P C, as 1363·1, which line does not reverse, or at least was never seen reversed at Sherman.

100. The principal line in the spectrum of the corona. The corresponding line in the spectrum of iron is rather feeble, and on several occasions when the neighbouring lines of iron (1463, &c.) have been greatly disturbed, this has wholly failed to sympathise. Hence I have marked the Fe with a ?. Watts indicates a strong line of oxygen at 5315 A.

152 and 156. Observed only on one day, but verified by Prof. Emerson.

172. Called little C by Mr. Stoney.

179. Given by Lockyer as K 2054. Its position is a little uncertain ; it seems to coincide with neither of the dark lines at 2051 and 2054, but lies between them, a little nearer to 2051.

189. Rather a band than a line.

222. The position of this line, which, however, like 189, is rather a band, was determined by two series of careful micrometrical measurements.

It was first discovered in 1869 by Rayet, and has since been named "f" by Lorenzoni, who, ignorant of the previous work of several other observers, has claimed its discovery.

272 and 273. These lines were both reversed (by a narrow bright stripe running down the centre of the hroad hazy band) as constantly, whenever the seeing was good, as *h* or C itself. The observation was difficult, however, and required the most scrupulous exclusion of foreign light, and a careful adjustment of the slit in the plane of the solar image formed by these particular rays.

They were also found to be regularly reversed upon the body of the sun itself, in the *penumbra and immediate neighbourhood of every important spot.*

SOCIETIES AND ACADEMIES

CAMBRIDGE

Philosophical Society, Oct. 18.—The following were elected officers of the Society :—President : Prof. Humphry. Vice-Presidents : Prof. Cayley, Prof. Adams, Prof. Liveing. Treasurer : Dr. Campion. Secretaries, Messrs. Bonney, J. W. Clark, and Trotter. New Members of Council : Prof. Babington, Prof. Stokes, Mr. Hort, Dr. M. Foster. The following communications were made to the Society :—"On the form suggested by M. Tresca, and adopted by the Commission Internationale du système métrique, for the Mètres Internationaux," by Prof. Miller, F.R.S. "A Method for Drawing in Perspective ;" and "A Method for Levelling" (communicated), by Mr. J. C. W. Ellis. The nature of these papers does not admit of a brief abstract.

PARIS

Academy of Sciences, October 21.—M. Faye, president. In opening the meeting the President announced the death on that morning of M. Babinet, Member of the Academy, Physical Section.—M. Yvon Villarceau then read a note relative to a letter from M. Magnac on the use of chronometers at sea which he presented to the Academy. The note and letter related to the compensation and rating of chronometers, and in conclusion drew attention to the great and continuous care which ought to be devoted to this subject by the Transit of Venus Expedition of 1874.—M. Pasteur then read an answer to M. Fremy's two notes read at the meeting of the 7th October. M. Pasteur's observations were in support of his theory of the wine ferment coming from the husk of the grape. He concluded his observation as follows :—"I declare both the theory of the transformation of albuminous matters into ferment cells by contact with atmospheric oxygen, and that of hemeorganism, or the generation of ferment cells from fruit cells, to be erroneous."—Next came a vigorous reply from M. Chevreul to certain "allegations contained in a report, by M. A. Gruyer, on the International Exhibition of London, 1871." At the conclusion of the reply MM. E. Bequerel and Milne-Edwards made some remarks on the subject, when the matter dropped.—A note from M. R. Clausius, on the mechanical equation from which the 'viriel' theorem results was then read, and was followed by a note from M. A. de Caligny on the theory of the several systems of navigation locks, a long paper relating to various kinds of locks, sluices, floodgates, &c..—This was followed by the continuation of M. P. A. Favre and C. A. Valson's paper on crystalline dissociation. The authors find that potassium and ammonium alum are partially dissociated when rendered anhydrous, and that chromium-potassium alum, when rendered anhydrous and then washed, loses potassic sulphate. They also attribute the change from violet to green of solutions of chrome alum, when heated, to this cause, and state that there is nothing to prove that this is not the case with all alums.—M. C. Sédillot then presented a note on the phenomena of fermentation and their connection with pathological physiology. The note related to certain recent studies on zymology by M. F. Monoyer.—M. Tresca then asked the Academy to open a sealed packet deposited by him with it on September 9, 1870, and which contained the particulars of the secret place where he and General Morin had deposited the standard metre and kilogramme during the events of that time. He wished the Academy to open the depositary, and to place the standards in the hands of the Government.—M. Ed. Bureau then read a note on the value of characteristics deduced from the structure of the stem for the classification of the *Bignoniaceæ*.—The concluding portion of M. Max Marie's paper on the extension of the method of Cauchy to the study of double integrals, &c., followed.—A note from Ed. Jannettaz on the coloured rings produced in gypsum by pressure, and their connection with the ellipsoid of thermal conduction and with cleavage, was referred to the physical section, and M. C. Dareste's studies on the osteological types of osseous fishes was sent to the section of zoology. The commission for the Montyon prize for medicine and surgery received a memoir on the three "psoric acariens" of the Horse by M. P. J. Mégnin.—A communication from MM. Chevallier on the manufacture of amorphous phosphorous matches was sent to the commission on the unhealthy arts.—A suggestion for the use of the tension of liquid ammonia as a source of motive power in aerial navigation by M. Pollard was submitted to the commission on aerostation : and the *Phylloxera* commission received a note relative to a remedy for that pest from M. Chatelain.—M. Yvon Villarceau then communicated a letter on the elements and co-ordinates of the planet No. 123 from M. Stephan, and also an extract from a letter from M. de Magnac on the determination of longitude by chronometers.—M. Chasles presented a note from M. H. G. Zeuthen on quartic equations, of which one part is reduced to a direct double.—A letter from M. P. Volpicelli on the probable nature of the Saturnian rings, and on a meteor observed at Rome on the 31st of August, was then read.—M. Th. du Moncel read a note on the accidental currents which arise in telegraphic wires, one end of which remains isolated in the air, after which M. Pasteur presented a note, by M. Feltz, on the action of crystallisable sugar on Barreswil's cupro-tartaric reagent. The author's experiments tend to show that cane sugar acts on the reagent in the presence of an excess of alkali ; hence he distrusts all determinations made where both sugars are present. This paper was followed by a note from MM. Béchamp and Estor on the role of the microzymes during embryonic development.—M. Tarry then read a note on the aurora and magnetic storm of the 14th and 15th October.—M. E. Fournié demanded the opening of a sealed packet relating to cerebral physiology deposited by him on the 22nd of July, 1872, and after a note from M. G. Bandiera on a means of separating essence of citron from turpentine had been submitted to M. Dumas, the session adjourned.

BOOKS RECEIVED.

ENGLISH.—The Expressions of the Emotions in Man and Animals : C. Darwin (Murray).—The Causation of Sleep : James Capper, M.D. (Thin, Edinboro').—Underground Treasures ; how and where to find them : James Orton (Worthington and Co.).

FOREIGN.— Through Williams and Norgate.)—Ueber die Auflösung der Arten durch natürliche Zuchtwahl.—Ueber die Bedeutung der Entwickelung in der Naturgeschichte : Dr. A. Braun.—Sachs-register zu dem Repertorium : J. Schotte.

DIARY

THURSDAY, NOVEMBER 7.

LINNEAN SOCIETY, at 8.—On the "Piopio" of New Zealand (*Keropia crassirostris Gmel*) : T. H. Potts.—On the buds developed on leaves of *Malaxis* : George Dickie, M.D.

SUNDAY, NOVEMBER 10.

SUNDAY LECTURE SOCIETY, at 4 —On A Bar of Iron : John Hopkinson, D.Sc.

TUESDAY, NOVEMBER 12.

LONDON INSTITUTION, at 4 —On Nutrition : Prof. Rutherford. (Educational course.)

THURSDAY, NOVEMBER 14.

LONDON MATHEMATICAL SOCIETY, at 8.—Remarks on some Recent Generalisations of Algebra : the President —Sur les Fonctions Circulaires : M. Hermite —Investigation of the Disturbance produced by a Spherical Obstacle on the Waves of Sound : Hon. J. W. Strutt —On the Mechanical Description of a Cubic Curve : Prof. Cayley.—A Series of Models of Cubic Surfaces to Illustrate their Different Forms : Prof. Henrici.

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